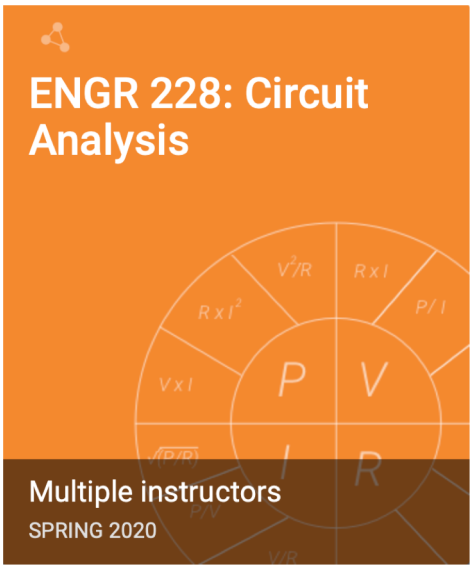


Chapter 1

Circuit Terminology

Engr228 - Circuit Analysis

Spring 2020

Dr Curtis Nelson

Chapter 1 Objectives

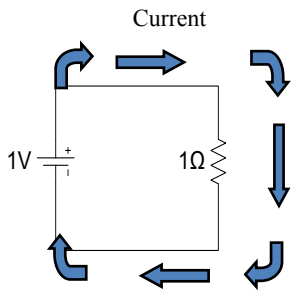
- Section 1.4: Learn how circuits are represented.
- Section 1.5: Learn to relate electric charge to current.
- Section 1.6: Learn to relate voltage to energy and apply the passive sign convention.
- Section 1.8: Learn to analyze the behavior of voltage and current sources, independent and dependent.

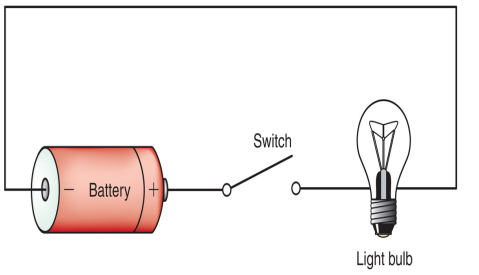
Standardized Prefixes to Signify Powers of 10

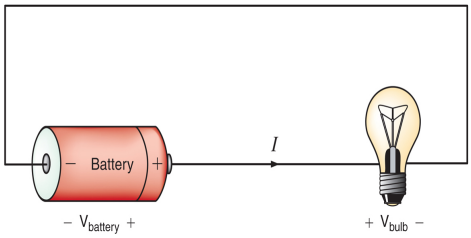
TABLE 1.3 Standardized Prefixes to Signify Powers of 10

Prefix	Symbol	Power
atto	a	10^{-18}
femto	f	10^{-15}
pico	p	10^{-12}
nano	n	10^{-9}
micro	μ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}
deka	da	10
hecto	h	10^{2}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}

Simple Circuit







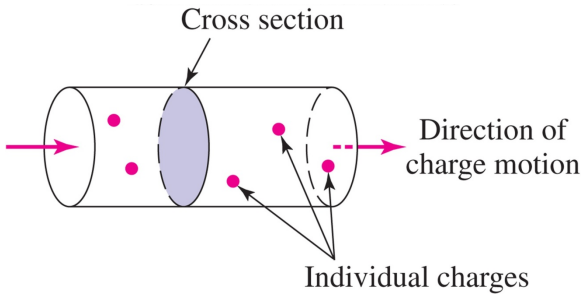
- Voltage
- Current
- Resistance

Charge (Q) and Current (I)

- The symbol for charge is Q or *q* and the unit is coulomb (C).
- Charge is bipolar, meaning that there can be either positive or negative charges.
- Electrical effects are attributed to both the separation of charge, *voltage*, and charges in motion, *current*. In other words, **voltage** is more like *potential energy* while **current** is more like *kinetic energy.*

Current

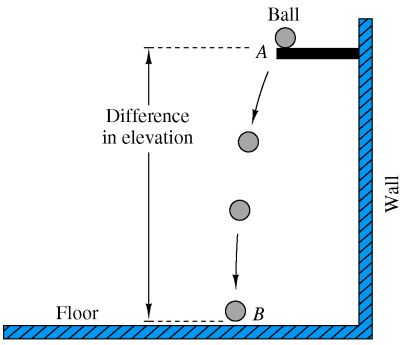
Current is the rate of charge flow: $\mathbf{I = dq/dt}$



Voltage and Potential Energy

Voltage (V or v)

- Voltage is the measure of work required to move charge through a circuit element.
- The unit of voltage is volt (V) = Joule/Coulomb = J/C.
- Voltage can exist between a pair of terminals whether a current is flowing or not. A battery is a good example of this.



Power and Energy

- Power is the time rate of expending or absorbing energy:

$$\mathbf{P = dw/dt}$$

where

P = the power in watts;
w = the energy in joules;
t = the time in seconds.

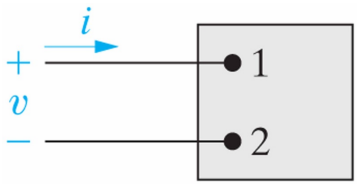
- From the definitions for current and voltage, power is also voltage times current:

P = VI or more precisely: **P = ±VI**

Passive Sign Convention

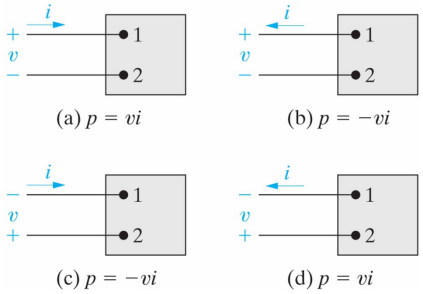
- Voltage and current can be either positive or negative, depending on how you specify a *reference*. To be consistent, we will adopt the **Passive Sign Convention**:

Whenever the reference direction for the current in an element is in the direction of the reference voltage drop across the element, use a positive sign in any expression that relates the voltage to the current. Otherwise, use a negative sign.



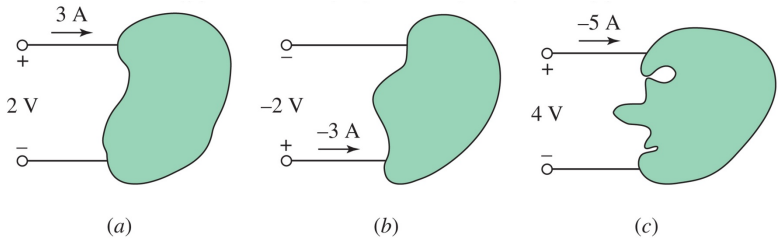
Power and the Passive Sign Convention

- Power is positive if the reference direction for the current is in the direction of the reference drop across the terminals of an element.
- When power is positive, the element is *absorbing* power.
- When power is negative, the element is *supplying* power.



Power and Energy – Practically Speaking

Power Example



How much power is absorbed by the three elements above?

$P_a = +6$ W $P_b = +6$ W $P_c = -20$ W

Note: (c) is actually supplying power

Textbook Problem 1.14 (Nilsson 11E)

- One 12 V battery supplies 100 mA to a boom box. How much energy does the battery supply in 4 hours?

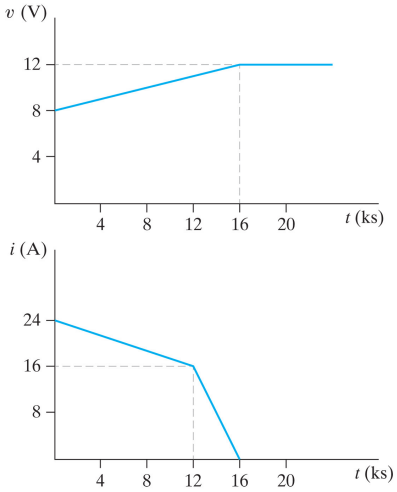
Power = VI = 12 (0.1) = 1.2 W

4 hours = 14,400 Seconds

Energy = integral of power = 17.28 kJ

Textbook Problem 1.27 (Nilsson 11E)

- The voltage and current at the terminals of an automobile battery are shown at the right. Calculate the total charge and energy transferred to the battery.



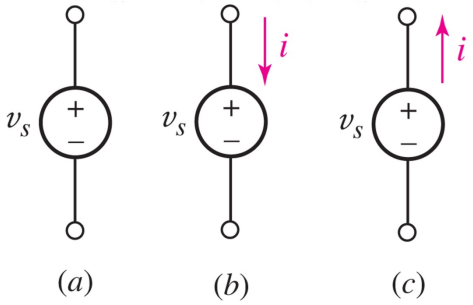
Charge = integral of current over time = 272kC
Energy = integral of power over time = 2619kJ

Various Circuit Elements

- Electric sources
  - Independent Sources – voltage, current;
  - Dependent Sources – voltage, current.
- Resistors, inductors, capacitors
- Measurement devices
  - Ammeters (current);
  - Voltmeters (volts);
  - Ohmmeters (resistance).
- Electric wire

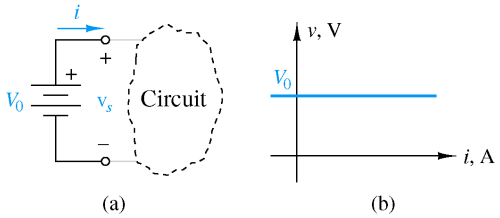
Independent Voltage Sources

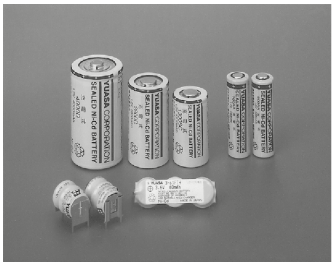
- An ideal voltage source is a circuit element that will maintain the specified voltage v_s across its terminals.



A Battery as an Independent Voltage Source

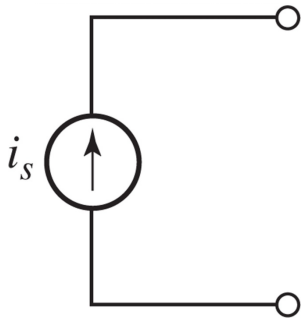
- An "ideal" battery is an example of an independent voltage source.
  - A "real-world" battery has a maximum power that it can deliver.





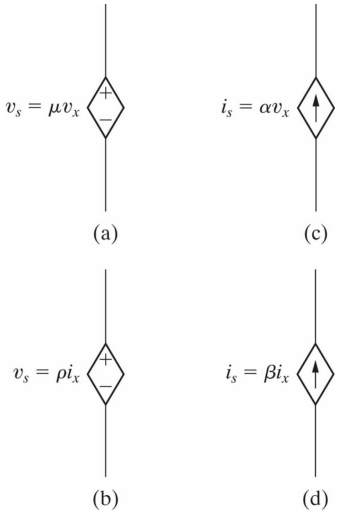
Independent Current Sources

- An ideal current source is a circuit element that maintains the specified current flow i_s through its terminals.



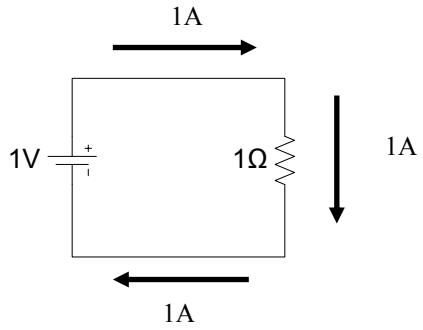
Dependent Voltage and Current Sources

- A *dependent* voltage or current source establishes a voltage or current whose value depends on a voltage or current elsewhere in the circuit.



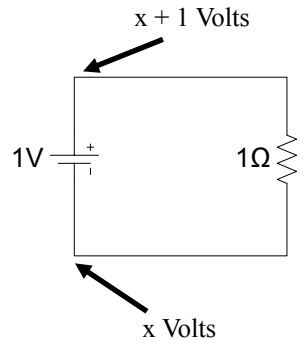
Current

- Current is the same in all elements connected in ***Series***.



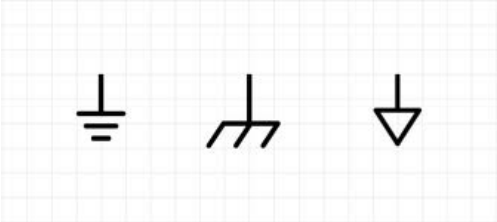
Voltage

- Voltage is the same for all elements connected in ***Parallel***.

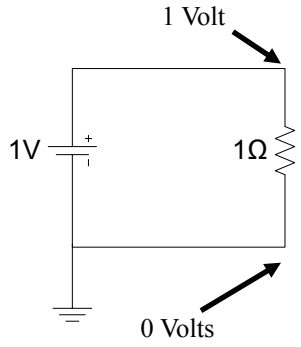


The Concept of Ground

- *Ground* is commonly referred to as a ***reference point.***
- *Ground* is said to be at a potential of 0.00 volts. In other words, *Ground* has zero voltage because it is referenced to itself.
- Ground symbols:

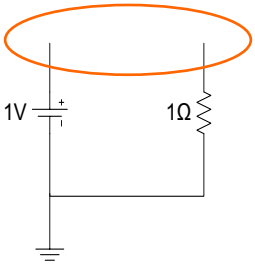


Ground



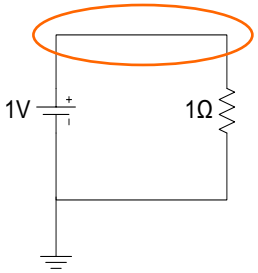
Open Circuit

- An *open circuit* means no current can flow ($i = 0$).
- *Voltage across* an open circuit can be any value.
- An open circuit is equivalent to a resistance of ∞ Ω.
- *Open circuit summary*:
  - Infinite resistance;
  - Zero current;
  - Voltage can be any value.



Short Circuit

- A *short circuit* means the voltage is zero ($v = 0$).
- *Current through* a short circuit can be any value.
- A short circuit is equivalent to a resistance of 0 Ω.
- *Short circuit summary*:
  - Zero resistance;
  - Zero voltage drop;
  - Current can be any value.



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